AFGL-TR-88-0027

Auroral Photography Experiment

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AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AIR FORCE BASE, MASSACHUSETTS 01731-5000

AFGL-TR-88-0027

AURORAL PHOTOGRAPH EXPERIMENT

"This technical report has been reviewed and is approved for publication"

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

In the framework of this program the Lockheed Palo Alto Research Laboratories is performing a joint experiment with AFGL to make observations of the aurora, airglow, shuttle induced emission effects such as surface discharge, shuttle glow and thruster induced effects. In this program the Air Force will be flying Lockheed instrumentation as a secondary payload on the shuttle and will make observations through the orbiter windows with the specialized equipment. The hardware is essentially a re-flight of the Auroral Photography Experiment (APE) which was flown on mission 41-G. Current status of the program is as follows:

1. All the Lockheed hardware was delivered to Johnson Space Center.
2. Most of the hardware has been qualified for flight.
3. Experiment Operation definition is in progress.
4. Data Analysis and scientific publication program is progressing with two papers submitted for publication.

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INTRODUCTION

Lockheed Palo Alto Research Laboratories is performing in collaboration with the Air Force Geophysics Laboratory an experiment to observe the aurora, airglow, shuttle induced emission effects. Among these effects observations will be made of the shuttle surface discharges during conditions of auroral bombardment, quiescent shuttle glow and thruster induced effects. The Lockheed tasks associated with this program are the providing of the experiment hardware and assisting the Air Force in the flight operations definitions, actual flight operations and data analysis. In addition there is an active parallel data analysis effort of the data taken on the prior APE experiment on the 41-G mission.

Experiment Hardware Activity

Much of the hardware flown on the first APE experiment was lost during the Challenger disaster. One of the first condition to permit the performance of the APE follow on experiment was the reproduction of the hardware which would be utilized in the APE experiment. The reproduced hardware was somewhat improved and its parameters were made more suitable for the APE experimental requirements.

Early in December, 1987 the APE 2 hardware was completed and was delivered to Johnson Space Center. Prior to delivery the instrument was calibrated for intensity response. This was accomplished with the various filters in an imaging mode and also in the spectrometer mode. In the spectrometer mode we have also obtained the function of spectral dispersion with linear distance on the image plane. For the absolute intensity calibrations we have used a C14 secondary standard.

The following hardware was delivered to JSC.

1. Image Intensifier
2. Spectrometer
3. F/1.2 lens
4. 8 filters
5. Filter changer
6. Filter pouch
7. Filter Carrier

The equipment in its different configuration is included as Figures 1 to 8 of this report.

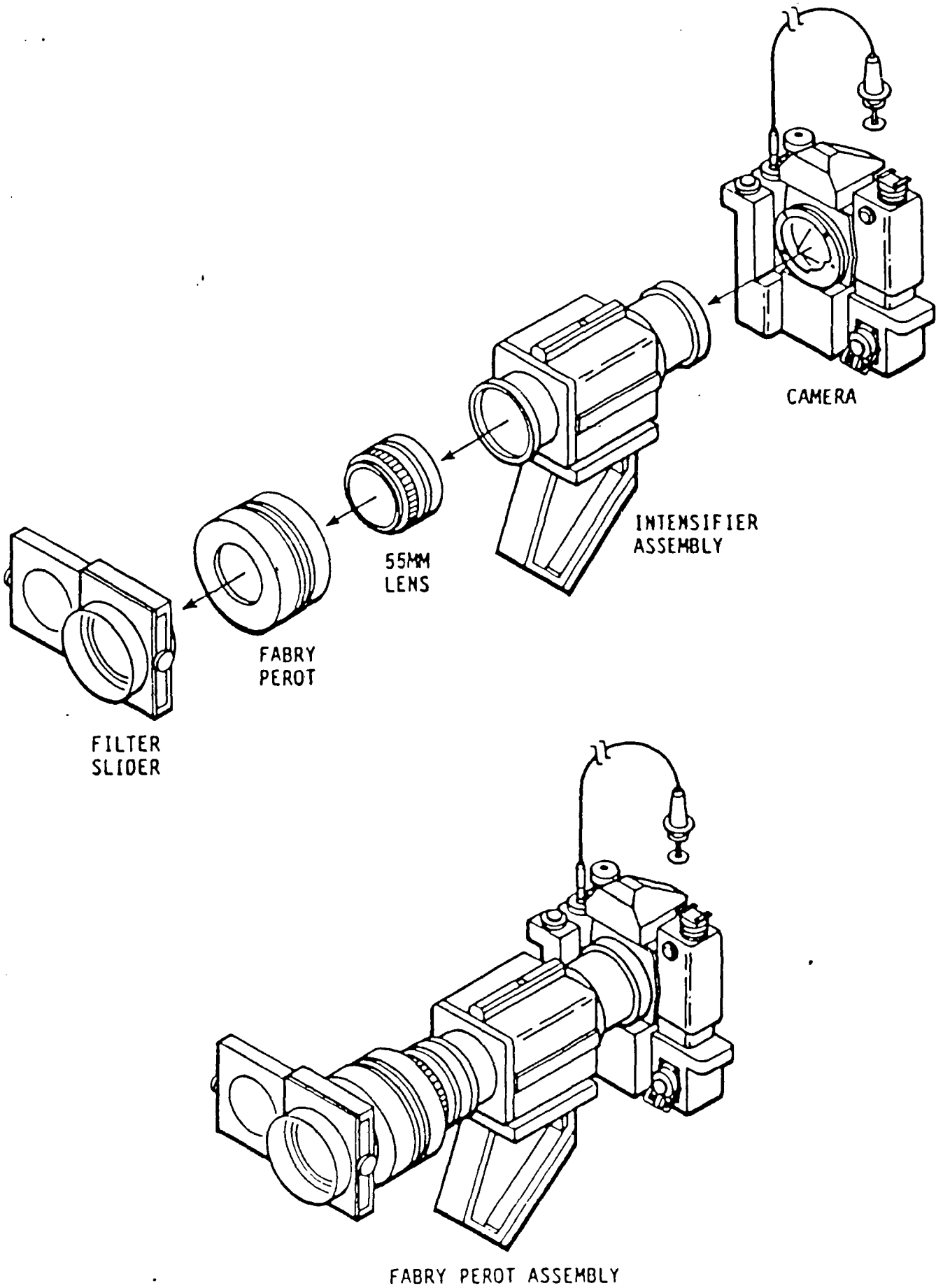
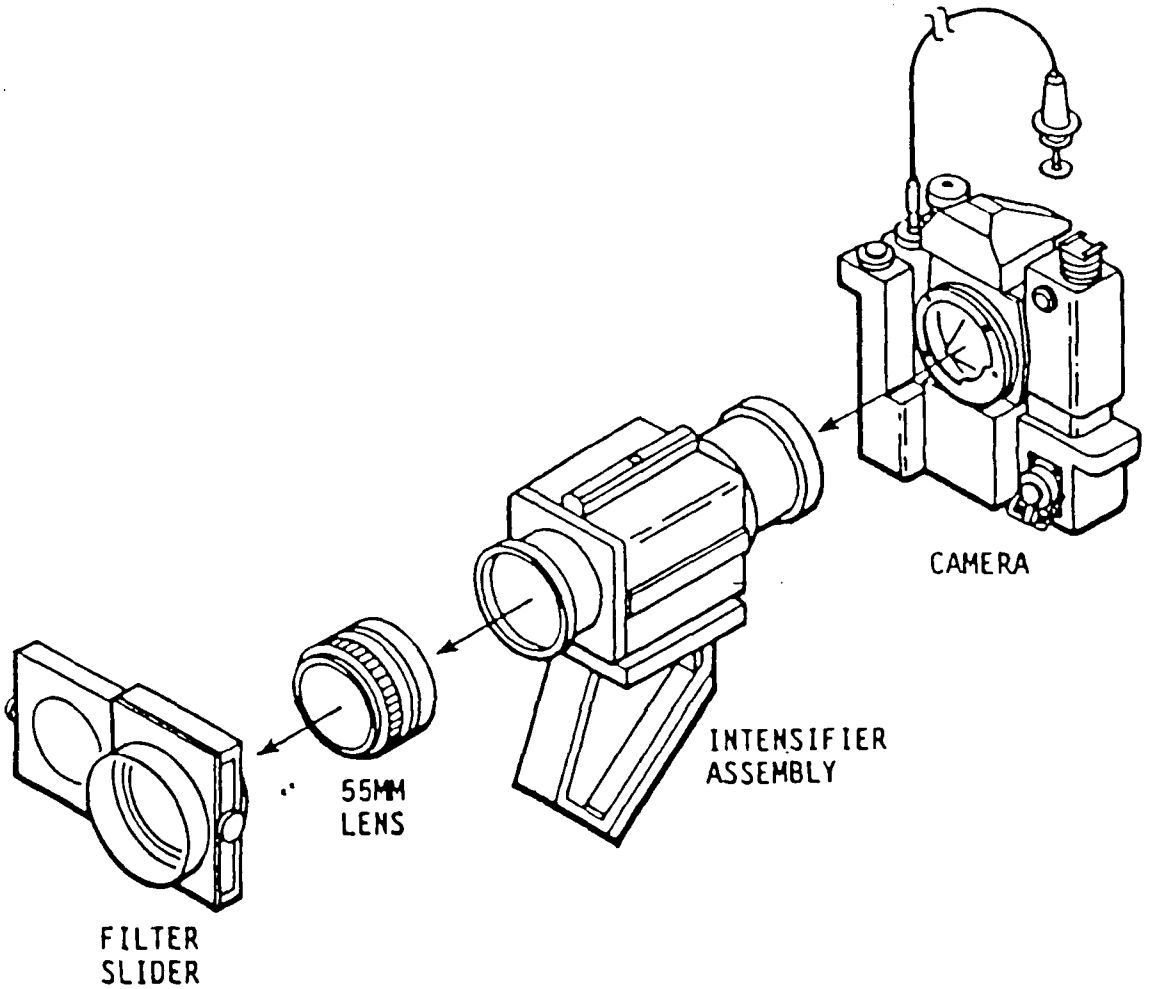


Figure 1: Fabry-Perot Equipment Configuration



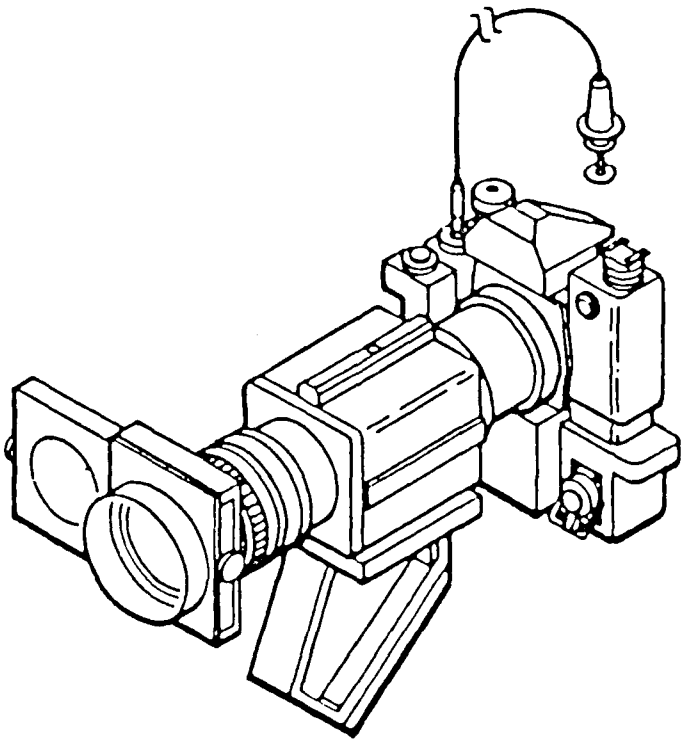


Figure 2 Image Photography Equipment Configuration

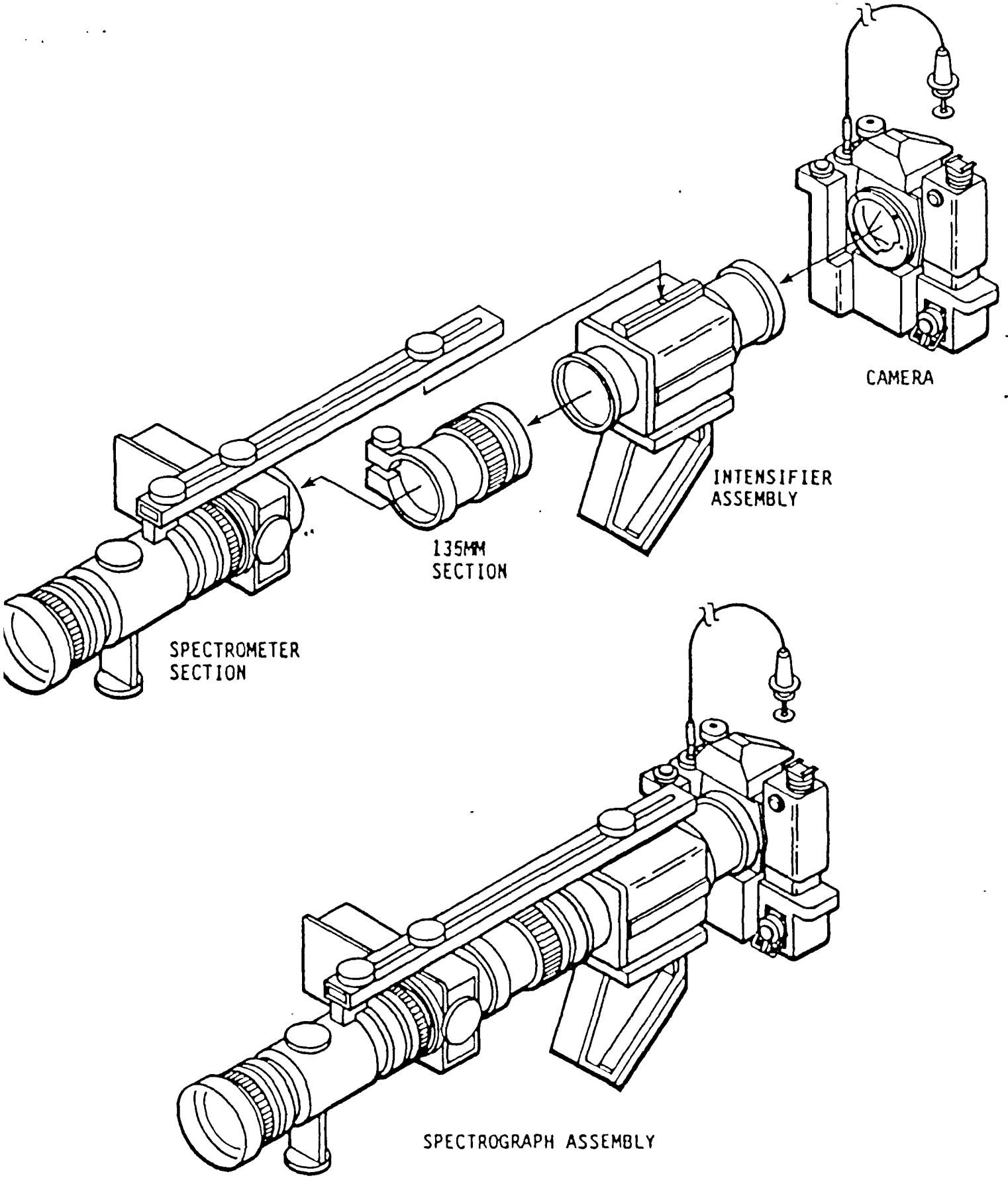
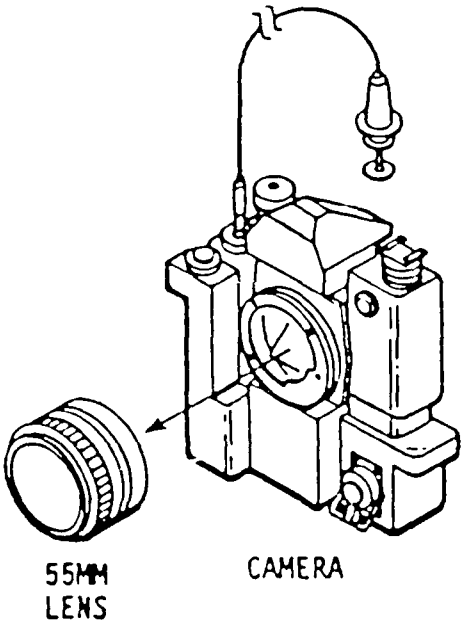
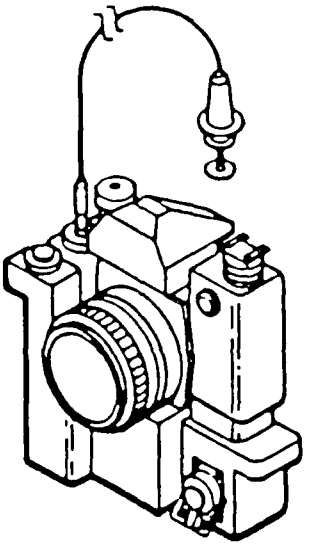


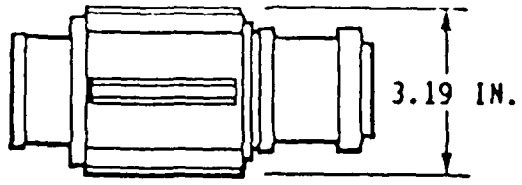
Figure 3 Spectrometer Equipment Configuration



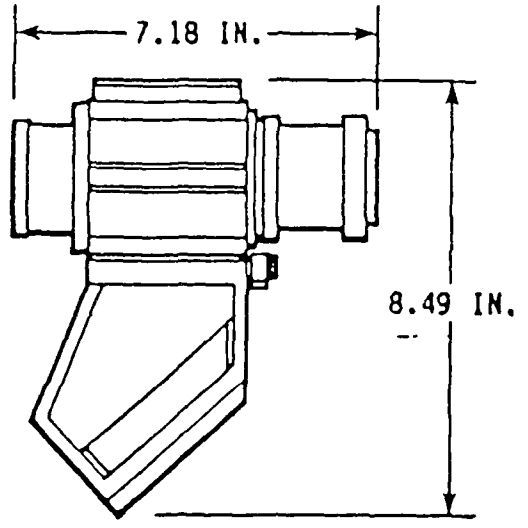


LENS ASSEMBLY

Figure 4 35mm Camera System with 55mm Lens

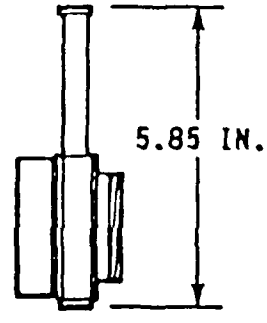


TOP VIEW

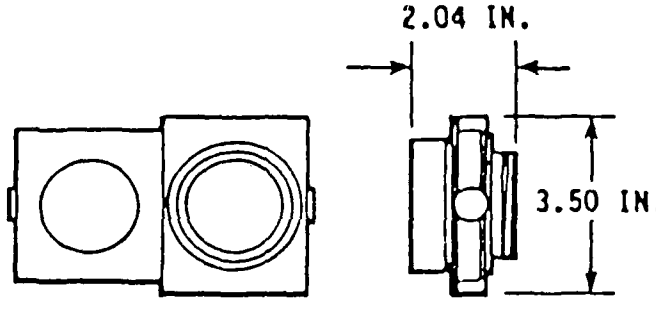


SIDE VIEW

INTENSIFIER ASSEMBLY



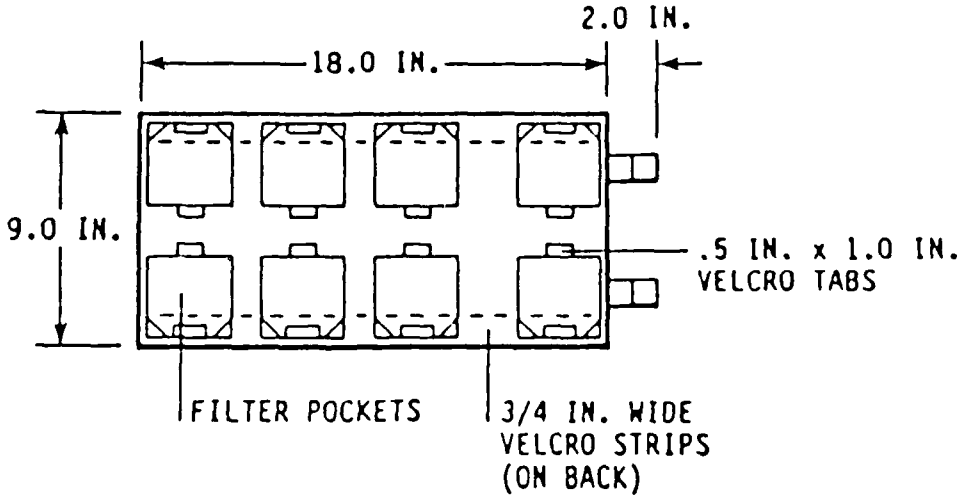
TOP VIEW



FRONT VIEW SIDE VIEW

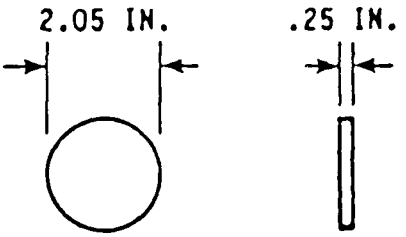
FILTER SLIDER ASSEMBLY

Figure 5 APE Configuration A & B Equipment



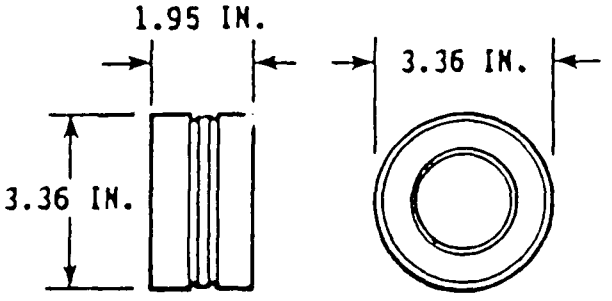
OPEN VIEW

FILTER POUCH



FRONT VIEW SIDE VIEW

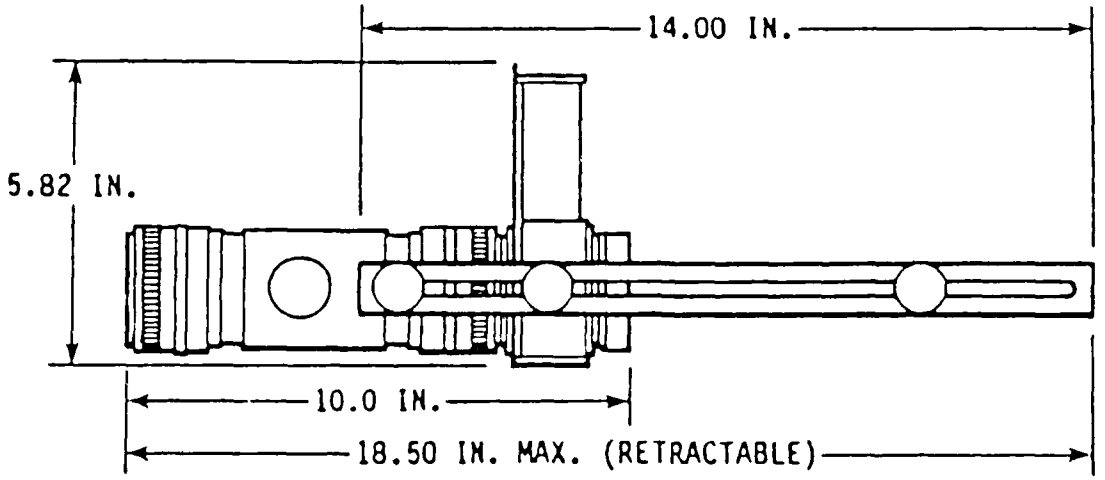
CAMERA/LENS FILTERS
(7 EACH)



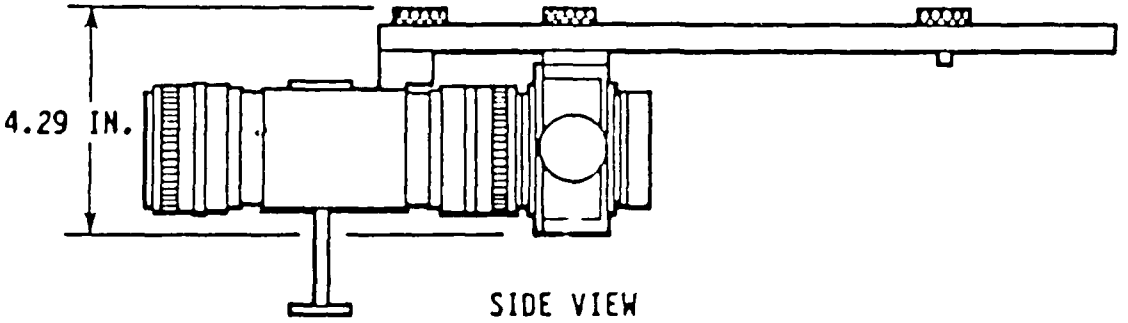
SIDE VIEW FRONT VIEW

FABRY PEROT

Figure 6 APE Configuration A & B Equipment (Cont'd)

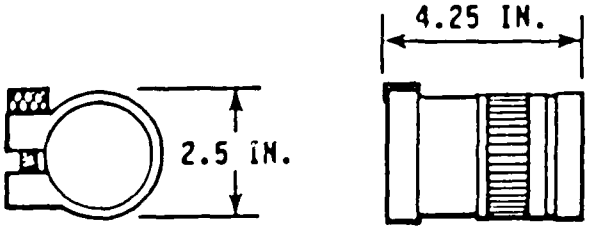


TOP VIEW



SIDE VIEW

SPECTROMETER



FRONT VIEW SIDE VIEW

135MM SECTION

Figure 7 APE Configuration B Equipment

Flight Operations Planning

There are essentially 4 functional objectives associated with the APE experiment:

1. Auroral and Airglow Photography
2. Auroral Effects on the Orbiter
3. Shuttle Glow
4. Thruster induced Effects

As part of the flight definition effort Lockheed assisted the Air Force and NASA in the preparation of the Payload Integration Plan (PIP).

Objective 1. Auroral and Airglow Photography

AURORAL OBSERVATIONS MAGNETIC LATITUDE >50 DEGREES

Auroral Spectrum

Assemble spectrometer.
Point spectrometer in imaging mode at limb airglow or limb auroral feature.
Align spectrograph slit vertically (perpendicular to limb airglow layer).
Take a 1/2 second exposure.
Introduce slit and grating.
Take a sequence of exposures 2 sec and 8 sec.
Remove slit and grating.
Take a 1/2 second exposure.
Repeat as many times as possible within observation window.

Auroral Photography

Assemble Fabry Perot, (if required) filter carrier, lens hood, and window hood. Point instrument at a limb auroral feature. Example of sequences:

Filter	Exposure Duration	Fabry-Perot
None	1/8 sec	None
7635	4 sec	
	1 sec	

None	1/8 sec
7325	4 sec
	16 sec
None	1/8 sec
5577	4 sec
	1 sec
None	1/8 sec
4270	4 sec
	1 sec
None	1/8 sec

Repeat

or

Filter	Exposure Duration	Fabry-Perot
None	1/8 sec	None
8447	4 sec	
	16 sec	
None	1/8 sec	
6300	4 sec	
	16 sec	
None	1/8 sec	
5577	1 sec	
None	1/8 sec	
4270	4 sec	
	1 sec	
None	1/8 sec	

or

Filter	Exposure Duration	Fabry-Perot
7325	2 sec	Yes
7325	8 sec	
None	1/2 sec	
7635	2 sec	
7635	8 sec	
None	1/2 sec	
8447	2 sec	
8447	8 sec	
None	1/2 sec	

AIRGLOW OBSERVATIONS MAGNETIC LATITUDE < 50 DEGREES

Preferred Window: Side hatch window with X LV (gravity gradient) and a slight roll to expose window into ram and wake.

Other Window: Aft flightdeck or Overhead window. Attitude to permit observation of the limb airglow layer.
Assemble Fabry Perot and filter carrier lens hood and window hood.

Filter	Exposure Duration	Fabry-Perot
7325	2 sec	Yes
7325	8 sec	
None	1/2 sec	
7635	2 sec	
7635	8 sec	
None	1/2 sec	
8447	2 sec	
8447	8 sec	
None	1/2 sec	

AIRGLOW PHOTOGRAPHY EQUATORIAL MAGNETIC LATITUDE < 15 DEGREES

Preferred Window: Side hatch window with X LV (gravity gradient) and a slight roll to expose window into ram and wake.

Other Window: Aft flightdeck or Overhead window. Attitude to permit observation of the limb airglow layer.

Assemble Fabry Perot and filter carrier lens hood and window hood.

Filter	Exposure Duration	Fabry-Perot
6300	2 sec	No
6300	8 sec	
None	1/2 sec	
5577	2 sec	
5577	8 sec	
None	1/2 sec	
7774	2 sec	
7774	8 sec	
None	1/2 sec	

Objective 2: Auroral Effects Photography

INITIAL CONDITION: Image Photography equipment configuration

Point and focus camera assembly at Orbiter surfaces exhibiting an electrical discharge or glow. Filters are not used for this objective.

Take a series of exposures at the following shutter speeds:

a) 1/30 sec
b) 1/8 sec
c) 1/2 sec
d) 2 sec
e) 8 sec

Repeat exposure series for other Orbiter surfaces exhibiting electrical discharge or glow.

Objective 3: Shuttle Glow Photography

INITIAL CONDITION: Image Photography equipment configuration

Point and focus camera assembly in imaging mode at any visible glow near surfaces exposed to the Orbiter's ram direction.

Take a series of exposures at the following shutter speeds:

a) 1/8 sec
b) 1/2 sec
c) 2 sec
d) 8 sec

Repeat exposure series for other Orbiter surfaces exposed to the ram direction exhibiting a visible glow.

NOTE: The procedure must be repeated at 2 minute intervals for the same Orbiter surfaces. Intent is to establish the dependence of the intensity of the glow as a function of time after crossing the dusk terminator to the dark side.

Objective 4. OMS/PRCS/VRCS Photography

INITIAL CONDITION: Spectrometer equipment configuration

Set camera to 1 second shutter speed.

Point and focus camera assembly at the Orbiter thruster area to photograph the exhaust plume emissions for the specific OMS, PRCS, or VRCS thruster.

Upon firing of the thruster, take a series of 5 exposures of the exhaust plume.

Repeat the series of 5 exposures for each thruster firing planned during this period of Orbiter darkness.

Criterion for Optimization of the Experiment Conditions

At the request of the Aerospace Corporation, Lockheed developed some criteria for optimizing the experiment conditions for a each of the functional objectives.

Objective 1. Auroral and Airglow Photography

Aurora

Moonphase	Latitude	Mag.Lat	Longitude	SolarElevAngl
New Moon	N/A	>50	N/A	<-18

Mid-latitude airglow

Moonphase	Latitude	Mag.Lat	Longitude	SolarElevAngl
New Moon	20 - 50		N/A	<-18

Equatorial airglow

Moonphase	Latitude	Mag.Lat	Longitude	SolarElevAngl
New Moon	N/A	<20	N/A	<-18

Objective 2. Auroral Effects on Orbiter

Moonphase	Latitude	Mag.Lat	Longitude	SolarElevAngl
New Moon	N/A	>60	N/A	<-18

Objective 3. Shuttle Glow

Moonphase	Latitude	Mag.Lat	Longitude	SolarElevAngl
New Moon	N/A	N/A	N/A	<-18

Objective 4. OMS/PRCS/VRCS Emissions

Moonphase	Latitude	Mag.Lat	Longitude	SolarElevAngl
New Moon	N/A	N/A	N/A	<-18

Material Certification

In reviewing the preliminary materials list supplied by Lockheed it was determined that the filter pouch material did not meet the flammability requirements. There was some misunderstanding about their suitability of the material and Lockheed produced the filter pouch under subcontract and the wrong material was used by accident. New filter pouch was produced and was delivered to *Johnson Space Center* in early May, 1988.

Recommendations and New Tasks

It was recommended by the JSC people working on the program that it would be highly beneficial to have a second set of hardware available for training.

It is anticipated that in the next quarter we will be participating in the mission definition and we will assist the Air Force in optimizing the time lines for the experiment objectives. It is hoped that in the next quarter the experiment selection would be finalized and we could start planning around a specific mission.

CONTRIBUTIONS

Scientists who contributed to the research in this document are:

S. B. Mende, G. R. Swenson and R. E. Meyerott

Publications and Reports

Two manuscripts which were partially sponsored by the contract were submitted for publication. These are:

Mende, S. B., G. R. Swenson, E. J. Llewellyn, W. F. Denig, D. J. W. Kendall, and T. G. Slanger, Measurements of Rotational Temperature in the Airglow with a Photometric Imaging Etalon Spectrometer. To be published in Journal of Geophys. Res., 1988.

Swenson, G. R. and R. E. Meyerott, Spacecraft Ram Cloud Atom Exchange and N2 LBH Glow. Geophys. Res. Letters 15, 245-248, 1988.